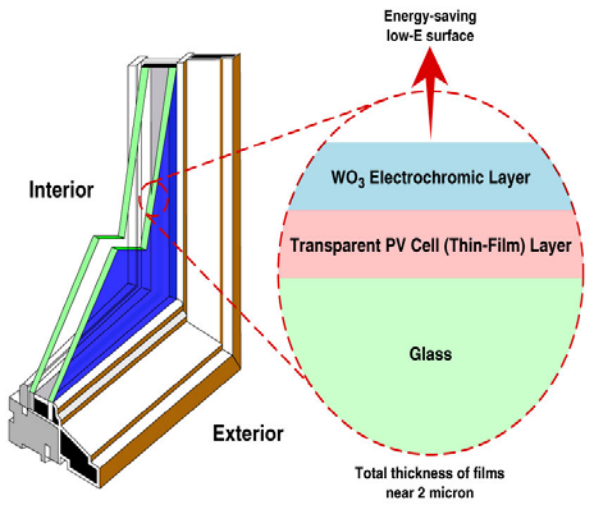
A national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy

National Renewable Energy Laboratory

Innovation for Our Energy Future

PowerView Semi-Transparent Photovoltaic Module – "Smart Glass"

NREL is excited to introduce a breakthrough solar-powered technology with multiple market applications. This new technology, the PowerView Semi-Transparent Photovoltaic Module or "Smart Glass" is a self-dimming, self-powered glass that combines photovoltaic (PV) technology with electrochromic (EC) technology. The technology operates by coating the inside surface of the glass with a transparent, thin film PV cell followed by an EC layer. The PV cell provides power to activate the EC layer, darkening or lightening the window. The smart glass window can block up to 98% of transmitted light and 100% of UV light all the time. The user can also control the amount of light transmitted through the glass.



There are many energy efficiency and comfort benefits. The smart glass mitigates solar heat gain, including heat build-up, in buildings, homes, and vehicles resulting in reduced energy costs and a gain in user comfort. The PV and EC films can also be applied to thin polymer films that can be retrofitted onto existing windows in homes, buildings, and vehicles. The advantage the NREL smart glass has over similar products, such as suspended particle devices, is that it is *self-powering*. The NREL smart glass does not need to be connected to the electrical system of a building, house, or vehicle in order to operate, reducing the installation and operational costs. A safety and aesthetic feature of the smart glass is that should it fail, it will fail clear.

The smart glass can be used in commercial, residential, and vehicle windows, for both new and retrofit applications. Interior glass windows, day lighting applications, skylights, walls, floors, and partitions can use the smart glass technology. Indoor signage and displays can be made using smart glass. The smart glass technology can also be applied to dynamic or high performance eyewear such as sunglasses, prescription glasses, goggles, and motorcycle visors.

There are several market applications for this type of technology. Such as the window market, encompassing commercial, residential, and replacement windows, and is estimated to be $15Billion in the U.S., $30-$45Billion worldwide. Higher energy efficient building codes at the federal and state levels, rising energy costs, the focus on cost containment, increasing productivity, the bottom line, and the increasing amount of time spent indoors are a few of the market drivers that this technology meets. Other market applications include the worldwide automotive glass market, valued at approximately $4Billion, larger if other vehicles are included; and the sunglass and goggle worldwide market, valued at an estimated $9Billion.

The value proposition for this technology is that the NREL “smart glass” can increase revenue by reducing energy costs, increasing worker productivity, and increasing sales revenue. This is supported by demonstrated demand for this type of technology in studies that estimate energy efficient windows saving, in peak energy periods, 4-5 Quads ($40-$50Billion/year) of energy per year. Worker productivity has been shown to increase by 6-15% by employing energy efficient building designs. The Electric Power Research Institute has shown that the use of daylight in buildings can result in a 10-20% increase in rental income. A 1999 PG&E study comparing stores utilizing daylight versus artificially lighted stores showed that stores with natural daylight had 40% higher sales. Large box stores like COSTCO, Home Depot, ToysRUs, IKEA are using natural daylight to reduce energy costs and to boost sales revenue.

Licensing Our Technology

NREL is looking for a strategic alliance to develop and commercialize this platform technology. The alliance could be a license, a Cooperative Research and Development Agreement (CRADA), or a Work For Others (WFO) that leverages NREL’s unique capabilities, facilities, and personnel. For additional information on NREL’s electrochromic program please visit the following website http://www.nrel.gov/basic_sciences/basicframe.html If you want additional technical information on this technology please contact Roland Pitts at **roland_pitts@nrel.gov**. If you are interested in partnering with NREL through a license or CRADA or WFO, please contact Richard Bolin at richard_bolin@nrel.gov.

Contact Information

If you would like to explore collaborative opportunities with the National Renewable Energy Laboratory please contact Richard Bolin, 303-275-3028.

Also for more technology transfer opportunities visit our Web site at www.nrel.gov/technologytransfer.

Associated Patent Abstracts

United States Patent 5,384,653
Benson , et al. January 24, 1995

Stand-alone photovoltaic (PV) powered electrochromic window

Abstract
A variable transmittance double pane window includes an electrochromic material that has been deposited on one pane of the window in conjunction with an array of photovoltaic cells deposited along an edge of the pane to produce the required electric power necessary to vary the effective transmittance of the window. A battery is placed in a parallel fashion to the array of photovoltaic cells to allow the user the ability to manually override the system when a desired transmittance is desired.

Inventors: Benson; David K. (Golden, CO); Crandall; Richard S. (Boulder, CO); Deb; Satyendra K. (Boulder, CO); Stone; Jack L. (Lakewood, CO)
Assignee: Midwest Research Institute (Kansas City, MO)
Appl. No.: 972242
Filed: November 6, 1992

United States Patent 5,377,037
Branz , et al. December 27, 1994

Electrochromic-photovoltaic film for light-sensitive control of optical transmittance

Abstract
A variable transmittance optical component includes an electrochromic material and a photovoltaic device-type thin film solar cell deposited in a tandem type, monolithic single coating over the component. A bleed resistor of a predetermined value is connected in series across the electrochromic material and photovoltaic device controlling the activation and deactivation of the electrochromic material. The electrical conductivity between the electrochromic material and the photovoltaic device is enhanced by interposing a transparent electrically conductive layer.

Inventors: Branz; Howard M. (Boulder, CO); Crandall; Richard S. (Golden, CO); Tracy; C. Edwin (Golden, CO)
Assignee: Midwest Research Institute (Kansas City, MO)
Appl. No.: 973171
Filed: November 6, 1992

United States Patent 5,716,736
Zhang , et al. February 10, 1998

Solid lithium-ion electrolyte

Abstract
The present invention relates to the composition of a solid lithium-ion electrolyte based on the Li.sub.2 O--CeO.sub.2 --SiO.sub.2 system having good transparent characteristics and high ion conductivity suitable for uses in lithium batteries, electrochromic devices and other electrochemical applications.

Inventors: Zhang; Ji-Guang (Golden, CO); Benson; David K. (Golden, CO); Tracy; C. Edwin (Golden, CO)
Assignee: Midwest Research Institute (Kansas City, MO)
Appl. No.: 540046
Filed: October 6, 1995

United States Patent 6,369,934
Bechinger , et al. April 9, 2002

Self bleaching photoelectrochemical-electrochromic device

Abstract
A photoelectrochemical-electrochromic device comprising a first transparent electrode and a second transparent electrode in parallel, spaced relation to each other. The first transparent electrode is electrically connected to the second transparent electrode. An electrochromic material is applied to the first transparent electrode and a nanoporous semiconductor film having a dye adsorbed therein is applied to the second transparent electrode. An electrolyte layer contacts the electrochromic material and the nanoporous semiconductor film. The electrolyte layer has a redox couple whereby upon application of light, the nanoporous semiconductor layer dye absorbs the light and the redox couple oxidizes producing an electric field across the device modulating the effective light transmittance through the device.

Inventors: Bechinger; Clemens S. (Konstanz, DE); Gregg; Brian A. (Golden, CO)
Assignee: Midwest Research Institute (Kansas City, MO)
Appl. No.: 631201
Filed: August 1, 2000

United States Patent 6,441,942
Branz , et al. August 27, 2002

Electrochromic projection and writing device

Abstract
A display and projection apparatus includes an electrochromic material and a photoconductive material deposited in tandem used in conjunction with a light filtering means for filtering light transmitted through the electrochromic material. When an electric field is applied across the electrochromic material and the photoconductive material, light that is incident onto the photoconductive material through the surface of the projection apparatus causes the photoconductive material to conduct current locally in proportion to the amount of light incident on the photoconductive material. The flow of current causes the underlying portions of the electrochromic material to switch from an opaque state to a clear or transmissive state, thereby allowing back-light to propagate through the electrochromic material to create a visible image on the surface of the projection apparatus. Reversal of the electric field causes the electrochromic material to revert back to its opaque state, thereby blocking the transmission of back-light and effectively erasing the image from the surface of the projection apparatus.

Inventors: Branz; Howard M. (Boulder, CO); Benson; David K. (Golden, CO)
Assignee: Midwest Research Institute (Kansas City, MO)
Appl. No.: 092475
Filed: September 25, 1998

United States Patent 6,420,071
Lee , et al. July 16, 2002

Method for improving the durability of ion insertion materials

Abstract
The invention provides a method of protecting an ion insertion material from the degradative effects of a liquid or gel-type electrolyte material by disposing a protective, solid ion conducting, electrically insulating, layer between the ion insertion layer and the liquid or gel-type electrolyte material. The invention further provides liquid or gel-type electrochemical cells having improved durability having a pair of electrodes, a pair of ion insertion layers sandwiched between the pair of electrodes, a pair of solid ion conducting layers sandwiched between the ion insertion layers, and a liquid or gel-type electrolyte material disposed between the solid ion conducting layers, where the solid ion conducting layer minimizes or prevents degradation of the faces of the ion insertion materials facing the liquid or gel-type electrolyte material. Electrochemical cells of this invention having increased durability include secondary lithium batteries and electrochromic devices.

Inventors: Lee; Se-Hee (Lakewood, CO); Tracy; C. Edwin (Golden, CO); Cheong; Hyeonsik M. (Seoul, KR)
Assignee: Midwest Research Institute (Kansas City, MO)
Appl. No.: 532168
Filed: March 21, 2000
